

**LIFE BENEATH GLACIAL ICE – EARTH (!) MARS (?) EUROPA (?)**

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We are investigating a set of cold springs that deposit sulfur and carbonate minerals on the surface of a Canadian arctic glacier. The spring waters and mineral deposits contain microorganisms, as well as clear evidence that biological processes mediate subglacial chemistry, mineralogy, and isotope fractionation. The formation of native sulphur and associated deposits are related to bacterially mediated reduction and oxidation of sulphur below the glacier. A non-volcanic, topography driven geothermal system, harboring a microbiological community, operates in an extremely cold environment and discharges through solid ice.

Microbial life can thus exist in isolated geothermal refuges despite long-term subfreezing surface conditions. Earth history includes several periods of essentially total glaciation. Ice in the near subsurface of Mars may have discharged liquid water in the recent past. Cracks in the ice crust of Europa have apparently allowed the release of water to the surface. Chemolithotrophic bacteria, such as those in the Canadian springs, could have survived beneath the ice of "Snowball Earth", and life forms with similar characteristics might exist beneath the ice of Mars or Europa. Discharges of water from such refuges may have brought to the surface living microbes, as well as long-lasting chemical, mineralogical, and isotopic indications of subsurface life.